March 13, 2001 Version

Determination of Mat Density Differentials Using the Nuclear Density Gauge

(Interim WSDOT Test Method – For use in information gathering during the 2001-paving season)

INTRODUCTION

The following interim test method constitutes an evaluation process for the 2001 paving season. The overall goal is to allow WSDOT and Contractor field personnel to systematically measure variations in mat densities due to temperature differentials or aggregate segregation for their site and laydown equipment combinations. The described test method will identify density variations due to both causes. This test method is for information generation only—it is not to be a contractual requirement. Following completion of the paving season, all data will be summarized and conclusions drawn. The results will be widely distributed including presentation at the APAW Annual Meeting (November 2001). One outcome should be how to control mat density differentials to acceptable levels in the most cost effective manner. The interim test method follows.

1. GENERAL SCOPE

a. The objective of this test method is to give guidance on establishing a density profile behind the laydown machine. This is accomplished by taking multiple density readings within a 50-foot section.
b. A density profile shall be performed on locations that include thermal differentials or aggregate segregation.
c. Asphalt concrete density measurements are made using a nuclear moisture density gauge in the backscatter or thin layer mode of transmission.
d. A density measurement shall be the average of two density readings taken in the same location at 90 degrees from each other. The readings should agree within 1.0 lbs/ft^3 (16 kg/m^3) of the average. If the readings do not agree within the 1.0 lb/ft^3, take a maximum of four readings, throw out the highest and lowest readings (one in each direction), and average.
e. On the basis of specified acceptance criteria, the results are used to determine the variability of mat density.
f. The Contractor shall not be required to change their operations in any way due to the results obtained herein, but may attempt to reduce the density differentials if they so choose.

2. EQUIPMENT

a. Handheld noncontact infrared thermometers (features should include continuous reading, minimum, maximum, and average readings, laser sighting, and a minimum distance to spot size ratio (D:S) of 30:1. The Raytek Raynger ST 60 ProPlus or ST 80 ProPlus are examples of handhelds with the needed features).
b. Nuclear density gauge and standardizing block (reference standard).
c. Tape measure.
d. A can of spray paint or crayons for marking test locations.

e. Required report forms.

3. GAUGE CALIBRATION

a. Follow the gauge calibration as outlined in Operator's Manual.
b. Locate the test site as described in the Density Profile section.
c. Density profiles on asphalt concrete pavement shall be made in the backscatter or thin layer mode of transmission.
d. Gauge-core correlation is not required for density profiles.

4. TEMPERATURE CRITERIA

When $\Delta T \geq 25^{o}F$ ($14^{o}C$) – Perform a minimum of two density profiles per day
When $\Delta T < 25^{o}F$ ($14^{o}C$) – Perform a minimum of one density profile per day

Normal Quality Assurance Testing will be performed throughout entire job in addition to any density profiles that will be performed.

5. USE OF HANDHELD NONCONTACT INFRARED THERMOMETER

a. Stand at the edge of the paving lane about 5 to 10 feet (1.5 to 3.0 meters) back from the paver.
b. Scan the mat with the handheld noncontact thermometer continuously in a longitudinal manner by walking behind the paver in the direction of paving, staying the same distance away from the paver for one truckload of hot mix. The offset for the longitudinal profile should be anywhere from 24 inches (0.6 meters) from the edge to no more than half the width of the mat. (The need to vary the longitudinal offset will be necessary to get an accurate representation of the whole mat.)
c. At the end of each longitudinal scan, make a separate transverse scan across the mat approximately 5 to 10 feet (1.5 to 3.0 meters) behind the screed to check for streaking of the mat.
d. View two truckloads of mix being laid on the mat at two separate offsets and observe the location and temperature of any cool spots. These observations should allow the operator to become familiar with the location and extent of the temperature differentials, if any.
e. Begin the longitudinal scan when a truck starts to dump into the paver or material transfer device and continue until the paver stops (discontinuous mix delivery) or until another truck starts to dump (continuous mix delivery). Perform a transverse scan after completion of the longitudinal scan, making sure to scan the entire width of the mat excluding the outer 24 inches (0.6 meters) on each side. Record the high and low temperatures on the mat within one truckload for the longitudinal and transverse profiles. (Include temperature measurements that have not been compacted or have not been on the mat for more than one minute.)
f. If the temperature differential is $25^{o}F$ ($14^{o}C$) or more, perform density profile. If the temperature differential is less than $25^{o}F$ ($14^{o}C$), there is no need to perform a density profile unless visible segregation is present. However, the minimum number of density profiles noted in Item 4 will be followed.

g. Record the affected areas starting point (also called zero point), offset, ΔT, type of temperature differential (spot or streak – see Figures 1 and 2), and if there is any visible segregation for testing and possible future evaluation. Typically, thermal differentials or segregation at the end of a truckload can be captured using the longitudinal scan and streaking will be captured by the transverse scan. The zero point is the beginning location of the spot or streak in the direction of paving.

6. DENSITY PROFILE PROCEDURE

a. A density profile is defined as a 50-foot (15 meters) length of mat with readings taken approximately every five feet (1.5 meters). Additional readings shall be taken wherever visible segregation is present. A density profile is taken following completion of rolling operations for that portion of pavement to be tested.
b. The zero point will be the starting point as indicated by the temperature profile. The first reading will be approximately 10 feet (3 meters) behind the zero point.
c. The transverse offset is determined by the location of the temperature profile and at least 24 inches (0.6 meters) or more from the pavement edge. Depending on the type of temperature differential or segregation, the transverse offset may vary (see Figures 1 and 2). Visually observe the mat and note the surface texture along with the density profile. Make note of areas that appear to be segregated. Visually segregated areas, if any, must be included in the section to be checked with a density profile if along the same offset.
d. Take two 1-minute readings at 90^{o} with the nuclear density gauge in the backscatter or thin layer mode of transmission in the same location and record.
e. Before moving the gauge, average the two readings. Compare each individual reading to the average. If either of these readings vary more than 1.0 lb/ft^3 (16 kg/m^3) from the average, take additional readings until two readings at 90^{o} of each other have been obtained that are within 1.0 lb/ft^3 (16 kg/m^3) of the average and discard all other readings (maximum of four readings). If these readings are still not within 1.0 lb/ft^3 of the average, throw out the high and low and average the two readings (one in each direction), and move on.
f. Move the gauge approximately 5 feet (1.5 meters) forward in the direction of the paving operation. If a segregated area is visible in between the 5-foot (1.5 meter) distance, take an additional set of readings at that location.
g. Repeat steps d, e, and f. Continue to take readings until a minimum 50-foot section has been covered. There should be a minimum of eleven sets of readings.
h. Determine the average density for the profile from each of the average readings. This is the mean reading.
i. Determine the highest average reading from the eleven sets. This is the maximum reading.
j. Determine the lowest average reading from the eleven sets. This is the minimum reading.
k. Determine the difference between the maximum (step i) and minimum (step j) readings. This is the maximum – minimum density range.
l. Determine the difference between the mean (step h) and minimum (step j) readings. This is the mean – minimum density range.
m. Record and plot the data on the Nuclear Density Profile Form. Report.

7. NUMBER AND LOCATION OF NUCLEAR DENSITY TESTS

a. The Engineer or Contractor shall take at least two temperature profiles per 400-ton lot.
b. No temperature of density profiles shall be performed on the first day of paving or until the roller pattern has been established.
c. No temperature or density profiles shall be performed within the first three delivered truckloads of production each day.
d. A minimum of two density profiles per day should be taken in areas where the temperature differential exceeds 25°F. A minimum of one density profile per day should be taken in areas where the temperature differential is less than 25°F.
e. Quality assurance testing will be performed according to FOP for WAQTC TM 8 and WSDOT Test Method 716.

8. REPORTING OF DATA

a. After each density profile has been run, the results should be reported to the Contractor and Engineer.
b. If the Contractor attempts to improve the density differentials by changing their operation, the change should be recorded on the form in as much detail as possible.
c. If there is a question regarding the use of the nuclear density gauge, please contact your Region materials lab. If there is a question regarding the density profile procedure, please contact Kim Willoughby at the Materials Laboratory in Tumwater: (360) 709-5474 or cell phone (360) 791-6038.
d. When the project has been finished, all data collection sheets should be forwarded to the Materials Laboratory, care of Kim Willoughby.

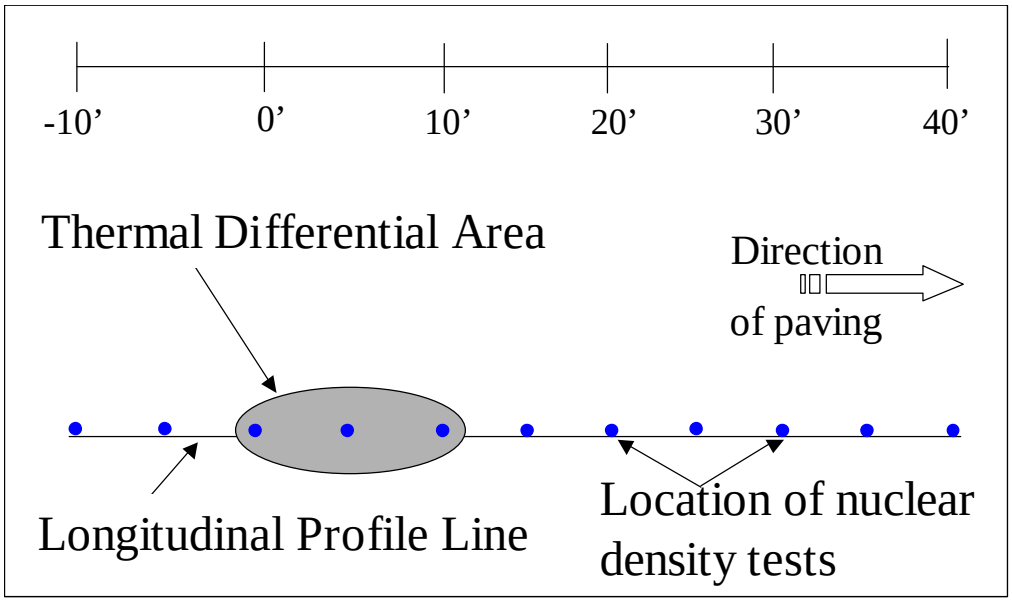

Figure 1a. Thermal differential as typical end dump (spot or chevron).

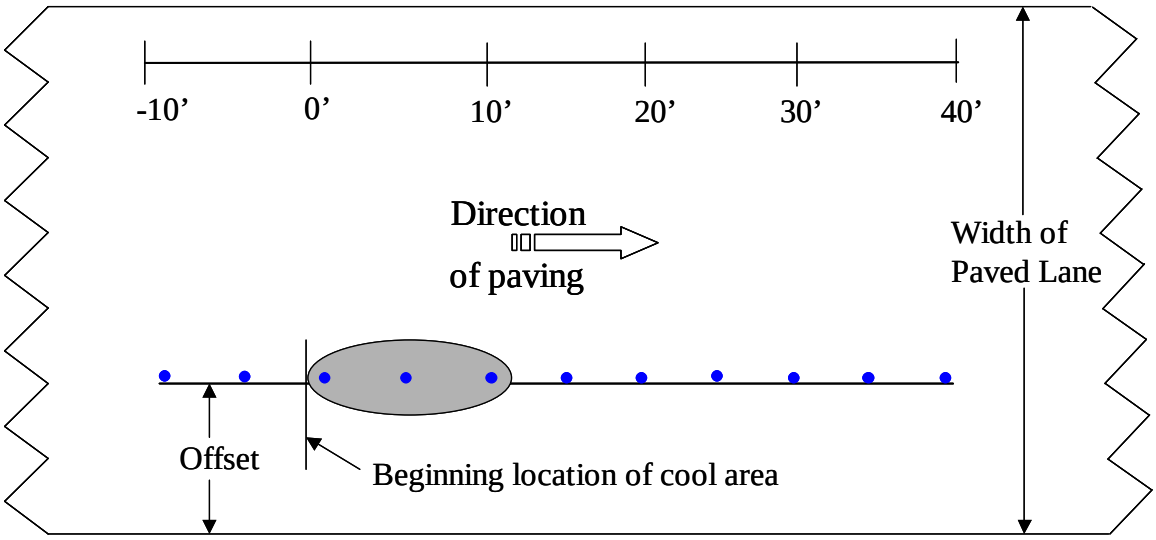

Figure 1b. Offset and location of temperature differential for longitudinal scan.

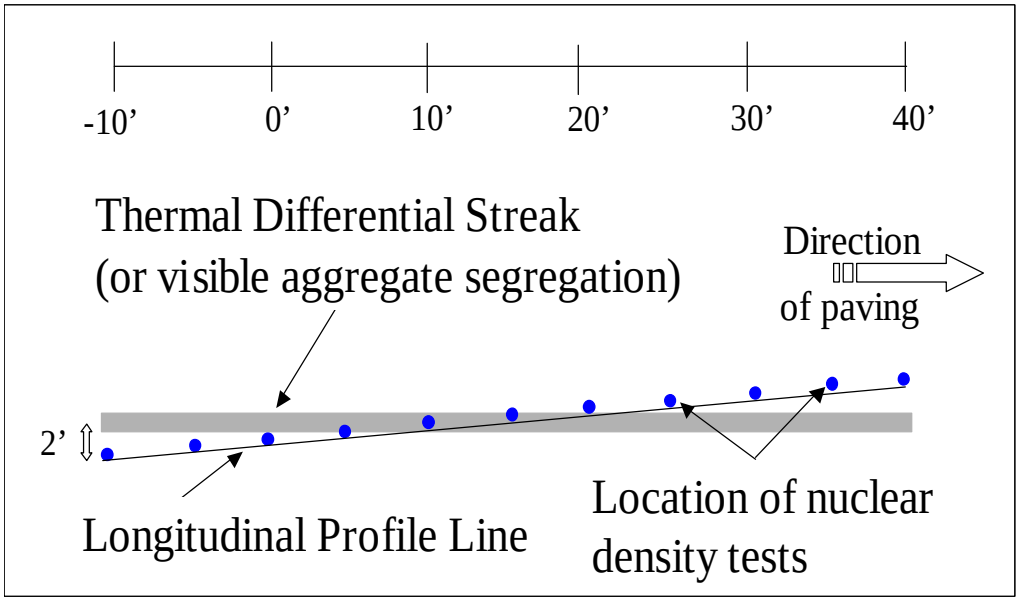

Figure 2a. Thermal differential or aggregate segregation in longitudinal streak.

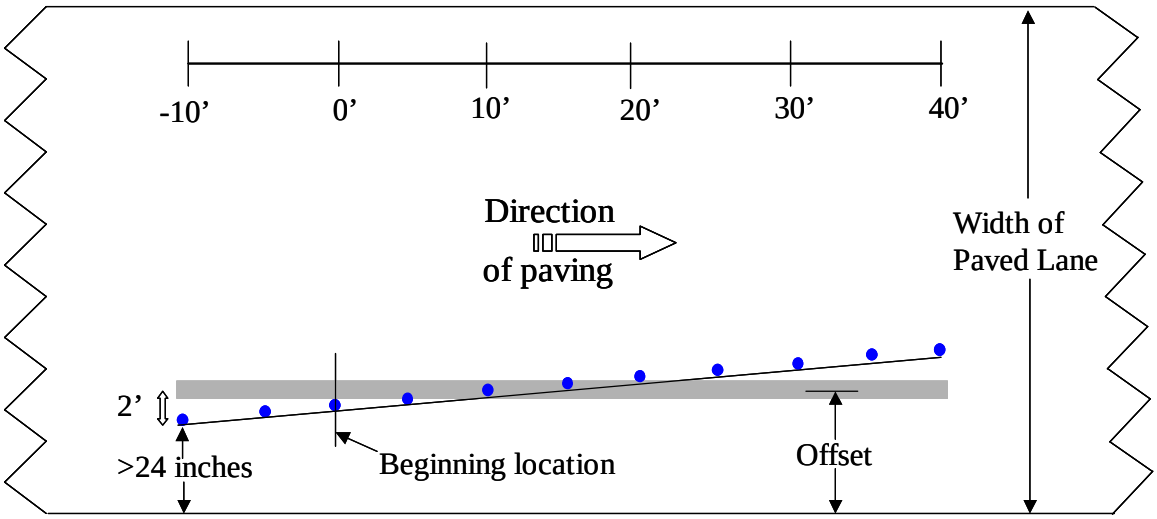

Figure 2b. Offset and location of temperature differential for transverse scan.

Nuclear Density Profile Form

Asphalt Concrete Pavement

Contract No.:	**Profile No.:**	**Location Information (1st Reading)**	
Route:	**Test Date:**	**Station/Milepost:**	
Region:	**Test Time:**	**Lane Direction:**	**Lane: 1 2 3 4 5**
Contractor:	**Wind Speed:** mph	**NB SB EB WB**	**Lift: wearing or base**
Tested By: DOT ☐	**Nuclear Gauge Operator**	**Offset From Outside Edge of Lane (ft):**	
Contractor ☐	**Name:**	**Edge conditions:**	**Confined**
Mix Type:	**Phone:**	**(C/L and shoulder)**	**Unconfined**
Lift Thickness:	**Visible Segregation: Yes** ☐	**Temperature Profile DT:**	
Width of Paving:	**No** ☐	**Type of DT: Truck Load or Streaks**	
Temperature of Mix	**Surface Temperature:** °F	**Ambient Air Temperature:** °F	
During loading: °F	**Haul Time:** min.	**Haul Distance:** miles	
Arrival at site	**Roller types being used (list brand and model number):**	**Circle one:**	
Internal temp in truck: °F	**Breakdown** Brand:_____ Model:_____	Vib/Pneu/Neither	
Crust of mix in truck: °F	**Intermediate** Brand:_____ Model:_____	Vib/Pneu/Neither	
Mat surface: °F	**Finish** Brand:_____ Model:_____	Vib/Pneu/Neither	
Internal mat: °F	**Other** Brand:_____ Model:_____	Vib/Pneu/Neither	

Vehicle Haul Type (circle one and list number of trucks):
Belly Dump Flow-boy Truck Truck and Pup # of trucks:_____

Covered Load:
Yes No Description:_____

Brand and Model of Paver (circle one and list model number):
Blaw-Knox Barber-Greene CAT Cedarapids Roadtec Other_____ Model:_____

Brand and Model of Remix Equipment (circle one, list brand name if necessary, and list model number):
Blaw-Knox Shuttle Buggy Windrow Elevator: Brand_____ None Other_____ Model:_____

	Feet from Prev. Read.	Readings (lb/ft³) 1st	2nd	3rd*	4th*	Average
1	0.0					
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						

Mean Reading	
Maximum Reading	
Minimum Reading	
Max Density Ranges:	
Maximum - Minimum	
Mean - Minimum	

Temperature Criteria

$\Delta T \geq 25^{o}F$

$\Delta T < 25^{o}F$

Density Criteria

Maximum - Minimum < 6.0 lb/ft³

Mean - Minimum < 3.0 lb/ft³

Provide the results of the Density Profiles to the Engineer or Contractor immediately.

*3rd or 4th readings are needed only if the average of the first two readings are not within 1.0 lb/ft³. The average should include two readings at 90°.

If changes have been made to the paving operation, please include a brief description of the changes:

Contract					Wind Speed			
Route					Width of Paving			
MTV/MTD Type					Haul Time			
Vehicle Haul Type					Lift Type			
Date	Time	Longitudinal ΔT	Offset Distance	Transverse ΔT	Average Mat Temperature	Visible Segregation?	Density Profile?	Special Conditions*
*Special Conditions refer to hopper wings being dumped, hot -mix spill on roadway prior to placement into MTV or paver, paving joints, etc.								